Documentation of MeteoSwiss Grid-Data Products

Monthly and Yearly Precipitation: RhiresM and RhiresY

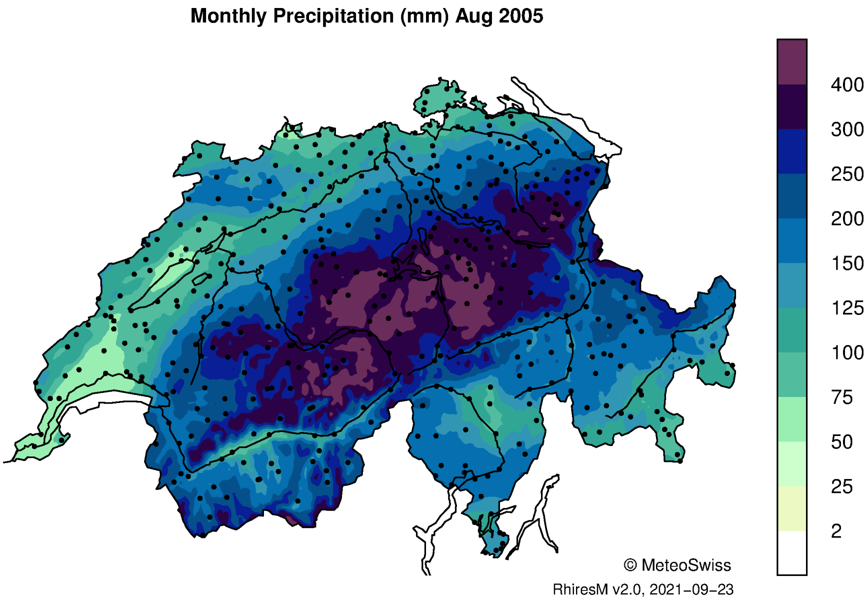

Figure 1: Monthly precipitation total (mm) and incorporated station measurements for August 2005

Variable Precipitation accumulated over the calendar months (the year), including rainfall and snowfall water equivalent. In millimeters (equivalent to liters per square meter).

Application Climate monitoring, ecology and agriculture, water resources, glaciology, hydropower, tourism.

Overview RhiresM and RhiresY are spatial analyses of monthly and yearly precipitation respectively, covering the territory of Switzerland. The analyses exploit all available rain-gauge measurements of the MeteoSwiss operational network (typically 430 stations), and they cover a multi-decadal period (1961-present). The two products address requirements of agronomists, ecologists and glaciologists running environmental process models at low time resolution. Also, the analyses are an important basis for climate monitoring and for planning and management tasks, such as for water resources, hydropower and tourism.

Data base

RhiresM/RhiresY are based on monthly/yearly precipitation totals measured at the high-resolution rain-gauge network of MeteoSwiss. The analyses use all station measurements available for a particular month to ensure maximum possible effective resolution. As a result, the station base varies over time (from month to month). The number of stations increases from 420 in the early 1960ies to about 520 in the mid 1970ies and gradually decreases thereafter, reaching 430 after 2005. 270 rain gauges (about 50% of the stations) come with an uninterrupted record since 1961.

The geographical distribution of rain-gauge stations in Switzerland is reasonably balanced in the horizontal (see e.g. Fig. 1), but there is a clear imbalance in the vertical, with regions above 1200 mMSL being comparatively under-represented (see e.g. Frei and Schär 1998, Konzelmann et al. 2007).

The majority of the rain gauges operated since 1961 are/were manual Hellmann type gauges with an orifice of 200 cm^2 positioned 1.5 m above ground. Since the early 1980ies approximately 70 stations are equipped with automatic tipping bucket gauges or, more recently, with weighing gauges.

Unlike RhiresD, the monthly and yearly analyses do not integrate station data from outside Switzerland and they are restricted to the domain within the country borders. This is related to issues of data quality with the real-time data deliveries and the fact that the station coverage is very coarse before the 1990ies over some of the foreign sections.

Method

A field of precipitation in month MM is obtained through the following procedure: (1) Spatial interpolation of the climatological mean precipitation measurements for the calendar month of MM (reference period 1971-1990, see Schwarb et al. 2001); (2) Calculation of relative anomalies of measured precipitation with respect to the climatological mean from step 1 (see Widmann and Bretherton 2000); (3) Spatial interpolation of relative anomalies (see section 4.1 of Frei et al. 2006); (4) Multiplication of the resulting anomaly field with the climatological mean field.

Detail on all these steps is provided in the product documentation for the daily precipitation analysis RhiresD, which the reader is referred to here. It is important to note that the analysis is conducted directly with the monthly/yearly point measurements, hence, RhiresM is not the temporal aggregate of daily fields from RhiresD. The smaller residual variance in step (3) when working with temporally aggregated measurements, implies smaller interpolation errors, and hence, more reliable estimates than the aggregation of more uncertain daily fields.

For version “v2.0” of RhiresM and RhiresY a manual adjustment has been applied to the original climatological background field of Schwarb et al. (2001) in order to amend unrealistically wet conditions in the region of the Jungfrau massif. The wet anomaly there was reduced by 23% for the annual total (25% in summer, 13% in winter) centered on the massif and gradually decreasing to zero over a radius of 25 km.

Again, for version “v2.0” of RhiresM and RhiresY, a slight modification has been made in the distance weighting scheme for better consistency with the change to “v2.0” in RhiresD (see the documentation for RhiresD).

Target users

Thanks to its multi-decadal extent (more than 50 years) and high effective resolution, RhiresM/RhiresY address the needs of a wide range of applications. In climatology, it is the primary data product for operational climate monitoring, research on climate variability and for climate change downscaling. Moreover, it is suitable as input into environmental process models in a variety of fields such as agriculture, ecology, hydrology and glaciology. Also, it provides an interesting data base for socio-economic planning and management tasks, such as for water resources, hydropower and tourism.

Accuracy and interpretation

The accuracy of RhiresM/RhiresY depends on the accuracy of the underlying rain-gauge measurements and the capability of the interpolation scheme to reproduce precipitation at un-gauged locations. There are limitations in both of these, which is explained in some detail in the product documentation for RhiresD. In short:

RhiresM and RhiresY must be expected to generally underestimate precipitation, particularly in months and at locations with snowfall, due to the measurement bias (Neff 1977, Yang et al. 1999). Estimates of the bias are 4% at low elevations in summer to more than 40% above 1500 mMSL in winter (Sevruk 1985).

Interpolation errors: A “leave one out” cross-validation reveals a relative standard error of +/– 20% in point estimates for Jura and the Swiss Plateau and of +/– 25-30% for the Alps and the Alpine south side. Seasonal variation of errors is small. Particularly large relative errors occur during dry months and in inner Alpine valleys (e.g. the Valais) as well as at high elevations in the Alps. The average fraction of explained spatial variance is 75% (Nash-Sutcliffe Efficiency, Nash and Sutcliffe 1970). It is to be noted that estimates of area mean values (obtained by averaging gridpoint values) are more accurate and error statistics are smaller when aggregating in space (see also Frei and Isotta 2019).

The RhiresM and RhiresY products are not strictly temporally consistent, because of inhomogeneities in the station data and variations in the station network. These products are not meant for analyses of long-term variations and trend. Users requiring high standards in long-term consistency are referred to the specific long-term datasets (RrecabsM1864 and RrecabsY1864).

Effective resolution: The km-scale spacing of gridpoints does not imply that these scales are fully resolved. The short-scale patterns (e.g. those evident in Fig. 1 above) are reflecting the topography-precipitation relationships estimated from the long-term mean. These, may be more or less representative of conditions in a single month (or a single year). We expect that the effective resolution of RhiresM is somewhere between the average station distance (around 15 km) and the grid spacing (1 km), likely near the upper end of the interval. Users interpreting the datasets at the scale of individual gridpoints should take into consideration that the estimates are subject to larger uncertainty. Frei and Isotta (2019) give a thorough discussion of short-scale uncertainty in gridded precipitation products.

Related products

RhiresM and RhiresY are mutually related in that the same analysis procedure is employed, with RhiresM taking monthly and RhiresY yearly precipitation measurements. But there is no strict consistency between the two products: Adding the months of a year from RhiresM does not strictly reproduce RhiresY. This is due to differences in the underlying station sample (not all stations cover the entire year). Differences are however insignificant in practice.

RhiresD: Similar to RhiresM but for the daily precipitation sum. Again, there is no strict consistency between the two products, i.e. adding the days of a month from RhiresD does not reproduce RhiresM exactly. Differences are however small in practice. If a monthly time-resolution is sufficient, product RhiresM should be preferred over the aggregation from RhiresD, because of higher reliability.

RanomM9120: Deviation from the climatological mean precipitation (reference norm period 1991-2020). This product is based on the sub-sample of stations for which there exist approved norm values. Hence RanomM9120 is of slightly inferior effective spatial resolution, but of superior temporal consistency. RanomM9120 is recommended for applications where comparability in time is important.

RrecabsM1864 / RrecabsY1864: These datasets are covering a much longer time period (back until 1864) than RhiresM / RhiresY. They meet very high standards in temporal consistency, thanks to the use of homogenized station data and the adoption of a reconstruction method, but they have a reduced effective spatial resolution. Users depending on high standards in temporal consistency are encouraged to use the reconstruction datasets.

Grid structures

RhiresM and RhiresY are available in the following grid structures:

ch02.lonlat, ch01r.swiss.lv95, ch.cosmo1.rotpol, ch.cosmo2.rotpol, ch.cosmo7.rotpol (analyses on cosmo grids are provided upon special request only)

Versions

v2.0: The current operational version of RhiresM and RhiresY

v1.0: This version was operational for many years until 2021. It has used a slightly different radial weighting scheme compared to v2.0, and has suffered an unrealistic moist anomaly in the Jungfrau region.

Update cycle

RhiresM is updated every month, RhiresY every year. The analysis for month *M* is available after day 25 of month *M+1*. The analysis for year *Y* is available in February of year *Y+1*.

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